



# Soft X-rays, white-light emission and densities in stellar flares with XMM-Newton

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A decorative graphic consisting of overlapping yellow, red, and blue squares with a black crosshair.

# Overview

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- ✓ White-light flares in the Sun and stars
- ✓ UV/optical and soft X-ray lightcurves of YZ CMi, EV Lac and AT Mic
- ✓ Density and temperature estimation with OVII triplet
- ✓ Correlations

A decorative graphic consisting of overlapping yellow, red, and blue squares with a black crosshair.

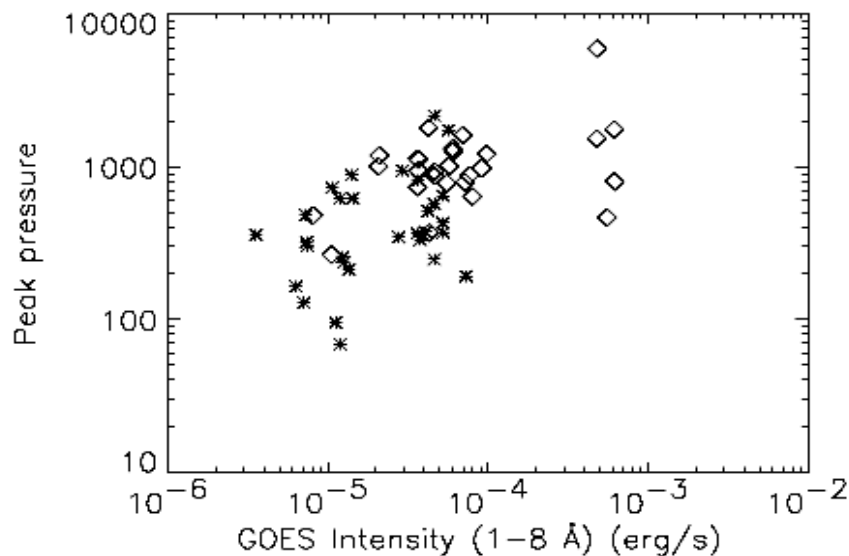
# White light flares

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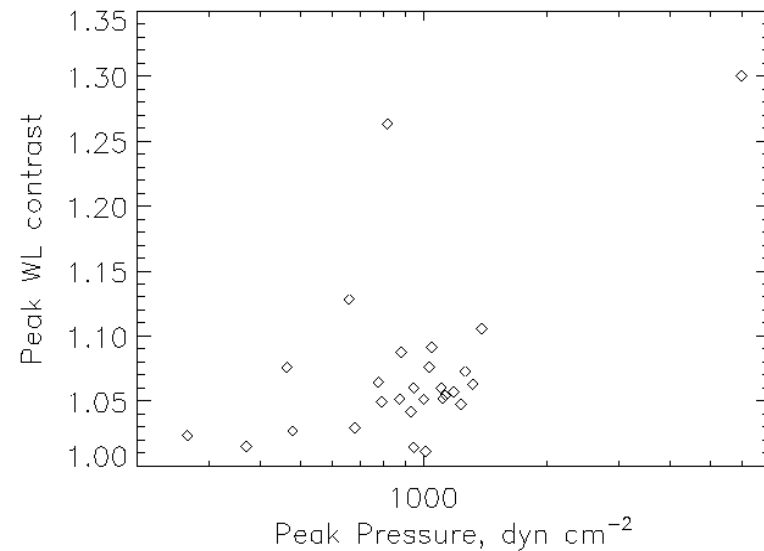
- ✓ Flares: Hard and soft X-ray energy release from reconnection in lower corona
- ✓ Some flares also show white-light (WL) emission
- ✓ White-light flares often observed in stars
- ✓ Rarely observed on Sun
- ✓ Only high intensity events show WL ?

# The Sun: WL vs pressure

- So far, only observed correlation with WL is coronal over-pressure (Matthews et al. 2003)



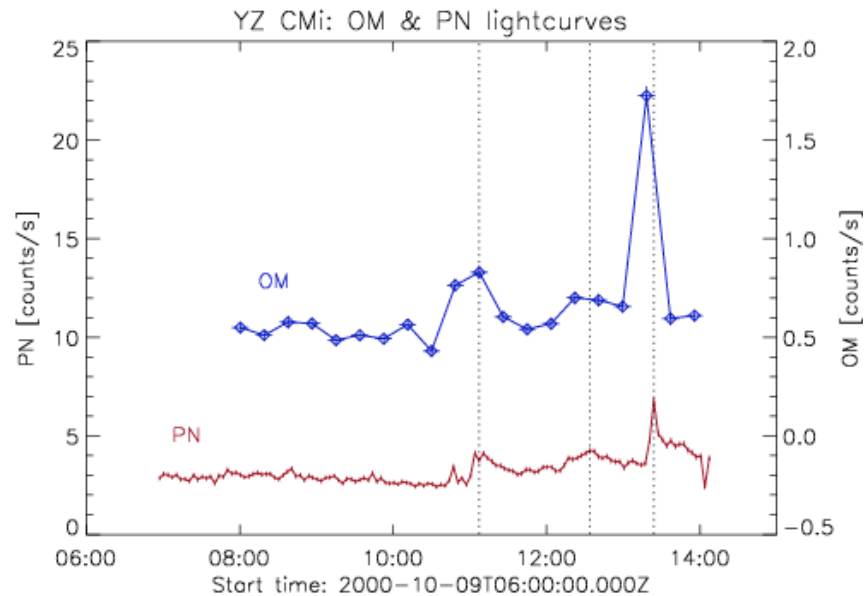
Diamonds: WL flares; Stars: Flares without WL



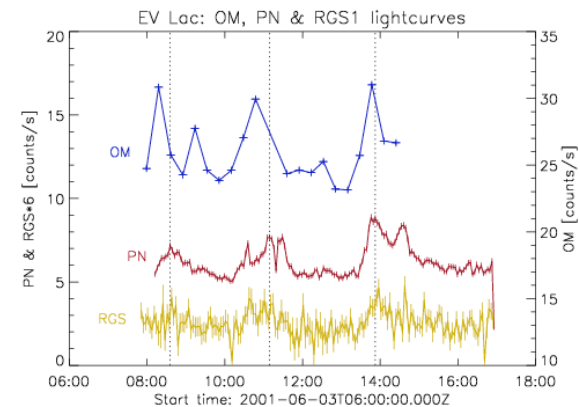
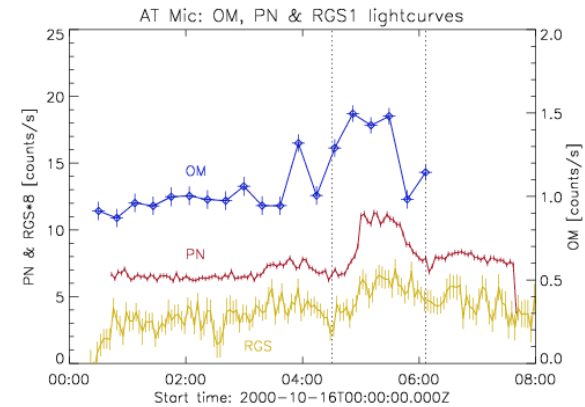
WL flares only

# Lightcurves

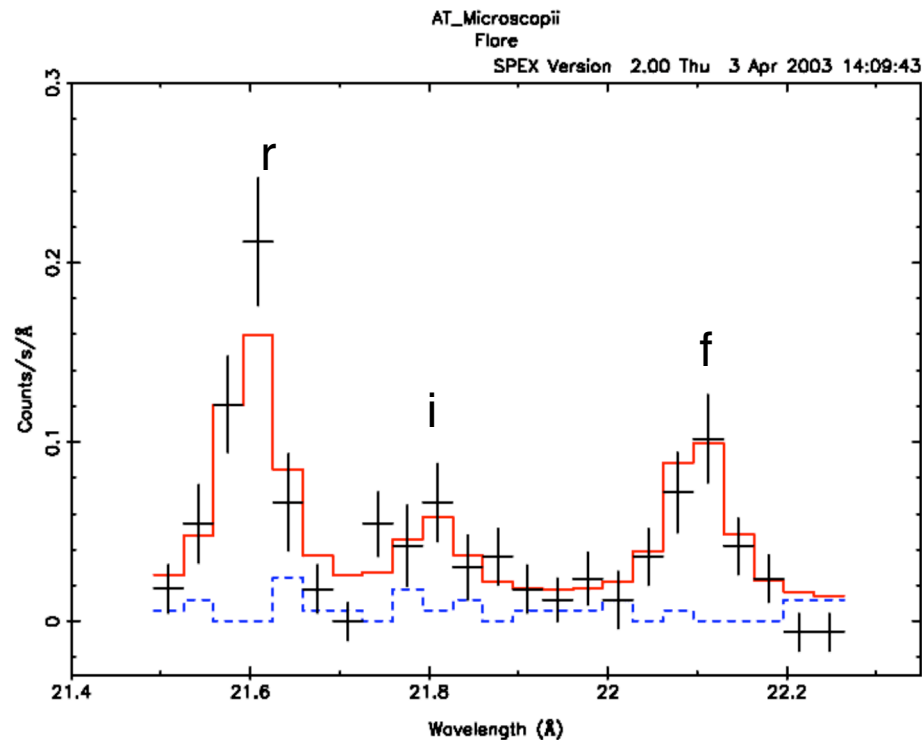
YZ CMi, AT Mic, EV Lac: dM4.5e stars



- PN: 0.2 – 10 keV
- RGS: 0.3 – 2.1 keV (38 – 5 Å)
- OM Filter: UVW2 180 – 225 nm, UVW1 225 – 350 nm
- OM flux: Integrated over 800s



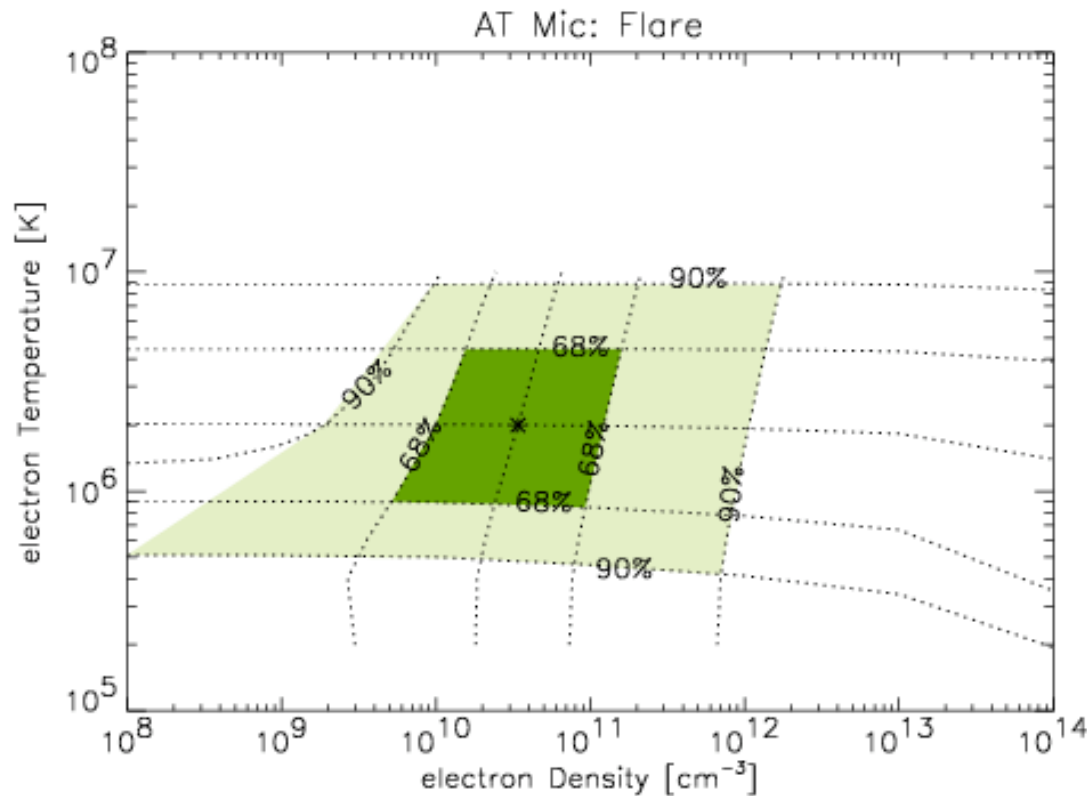
# Density diagnostic: OVII triplet



- ✓ R-ratio
  - ✓  $R = f/i$
  - ✓ Density sensitive
- ✓ G-ratio
  - ✓  $G = (f+i)/r$
  - ✓ Temperature sensitive

Spex: Kaastra et al. (1996)

# Density-Temperature Diagram



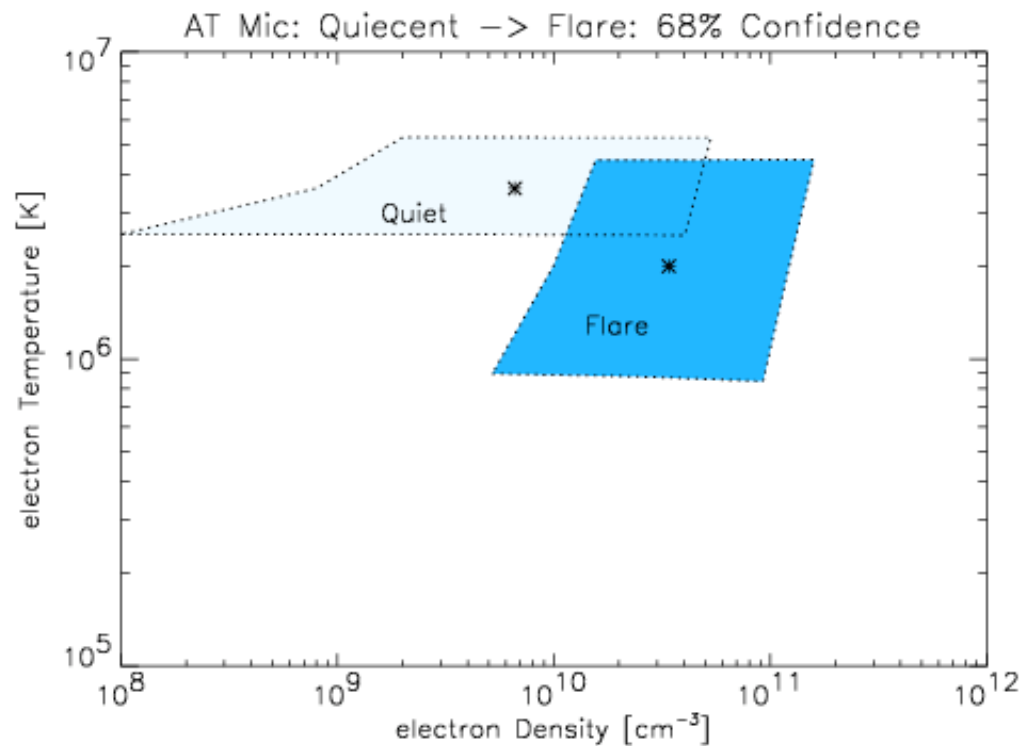
Chianti Database:  
Dere et al. (1997)  
Young et al. (2003)

$$\begin{aligned} n &= n(r, T) \\ T &= T(g, n) \end{aligned}$$



$$\begin{aligned} T &= T_r(n) \\ T &= T_g(n) \end{aligned}$$

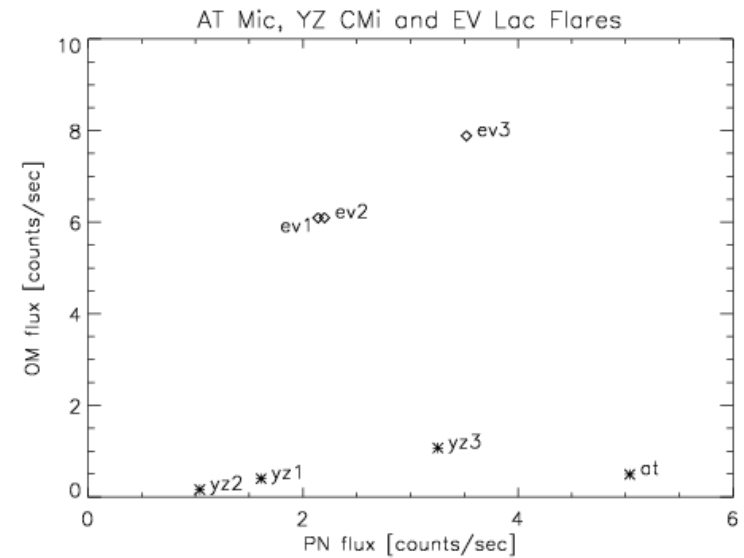
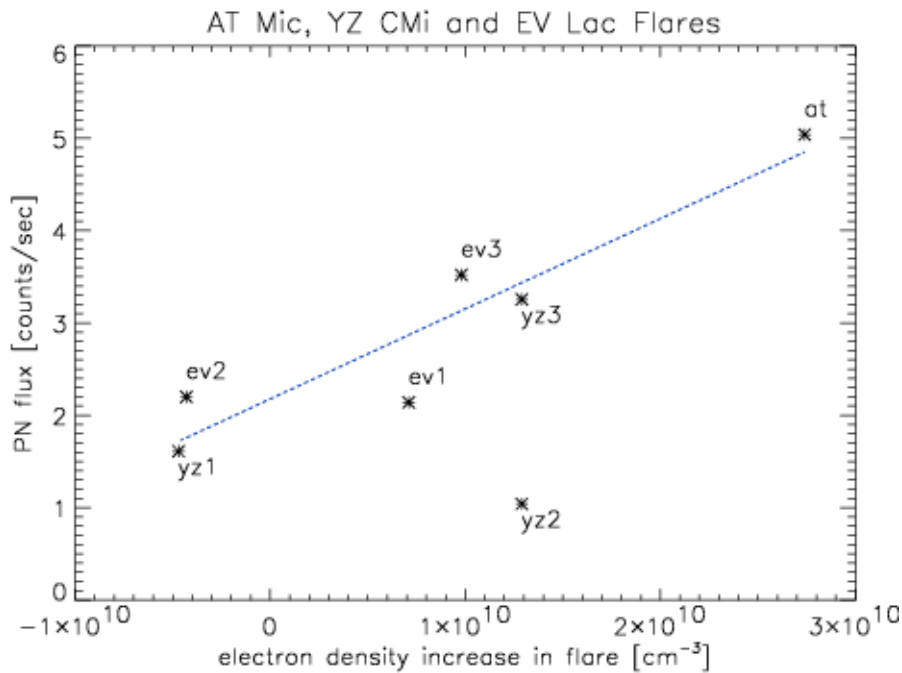
# Quiet vs Flare



Good agreement with:  
Raassen et al. (2003)  
Atomic Database:  
Porquet et al. (2001)



# Relations



For stars:  
Ness et al. (2002)

For the Sun:  
e.g. Feldman et al. (1996)



# Summary

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- ✓ Correlation between white light and soft X-rays
  - ✓ Future: Better time resolution for optical
- ✓ Density increase during flare
  - ✓ Large errors because of low count rates
- ✓ Relationship between soft X-rays and density in flares (within errors)